NAVAL POSTGRADUATE SCHOOL
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THESIS

MANAGEMENT OF THE FLEET SATELLITE COMMUNICATIONS SATELLITE ACQUISITION FOR THE NAVAL POSTGRADUATE SCHOOL

by

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Thesis Advisor: Rudolf Panholzer

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This thesis discusses the management of the acquisition of the Fleet Satellite Communications Satellite (FLTSATCOM) Qualification Model for the Naval Postgraduate School. The preparations, scheduling, and accomplishment of the delivery and the efforts required to establish the FLTSATCOM laboratory are discussed. The interaction between the Naval Postgraduate School, various government agencies, and the FLTSATCOM prime contractor necessary to accomplish the project is also described.

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Management of the Fleet Satellite Communications Satellite Acquisition for the Naval Postgraduate School

by

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Lieutenant Commander, United States Navy
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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

This thesis discusses the management of the acquisition of the Fleet Satellite Communications Satellite (FLTSATCOM) Qualification Model for the Naval Postgraduate School. The preparations, scheduling, and accomplishment of the delivery and the efforts required to establish the FLTSATCOM laboratory are discussed. The interaction between the Naval Postgraduate School, various government agencies, and the FLTSATCOM prime contractor necessary to accomplish the project is also described.

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I. INTRODUCTION

A. BACKGROUND

Fleet Satellite Communications (FLTSATCOM) spacecraft are part of a worldwide Navy, Air Force, and Department of Defense communications system. The spacecraft are deployed in geostationary orbit and provide 23 communications channels in the 240 to 400 MHZ frequency band.[Ref. 1:p. 1]

The U.S. Navy manages the overall program, with the U.S. Air Force Space Systems Division (USAF/SSD) acting as the contracting agency for the space segment. TRW Inc. (TRW), is the prime contractor for the satellite.[Ref. 2:p. 1]

The first satellite of this type manufactured was a qualification model. This spacecraft was identical to the flight spacecraft with the exception of thrusters, which were not installed. It was built as a test platform to validate the design and was made operational in 1975. Subsequently, eight FLTSATCOM satellites were launched (six successfully) during the years of 1977 to 1989. The qualification model was retained by TRW to allow testing as required.[Ref. 3]

Space and Naval Warfare Systems Command (SPAWAR), the Navy office responsible for the management of the FLTSATCOM program, recognized an opportunity to use the qualification model for educational purposes at the Naval Postgraduate

School (NPS). The FLTSATCOM contract (FLTSATCOM Production Qualification Model Contract F04701-82-C-0007) between the government and TRW was due to expire in June 1990. This required all government property in TRW's possession (which included the qualification model satellite) to be returned to the government. Following consultations between SPAWAR representatives and the Chairman of the Space Systems Academic Group (SSAG) at NPS, a mutual decision was made to transfer the qualification model to NPS for use in a laboratory to demonstrate the spacecraft's internal systems (spacecraft bus). The communications package (payload) components were to be made available for use to the maximum extent possible without the installation of communications security equipment.[Ref. 4] Delivery was initially planned to occur before expiration of the FLTSATCOM contract [Ref. 3].

B. PROJECT DEFINITION

The transfer and setup of the FLTSATCOM qualification model at NPS required the use of many skills practiced in program management. Arrangements to accomplish the safe delivery of the satellite and its ground support equipment had to be made. Setup and testing of the satellite immediately after delivery to check its operability and provide training of NPS personnel was also desired. The challenge lay in coordinating the efforts of several government agencies as well as a defense contractor to achieve these

objectives. The problems requiring solution are outlined in the remainder of this chapter.

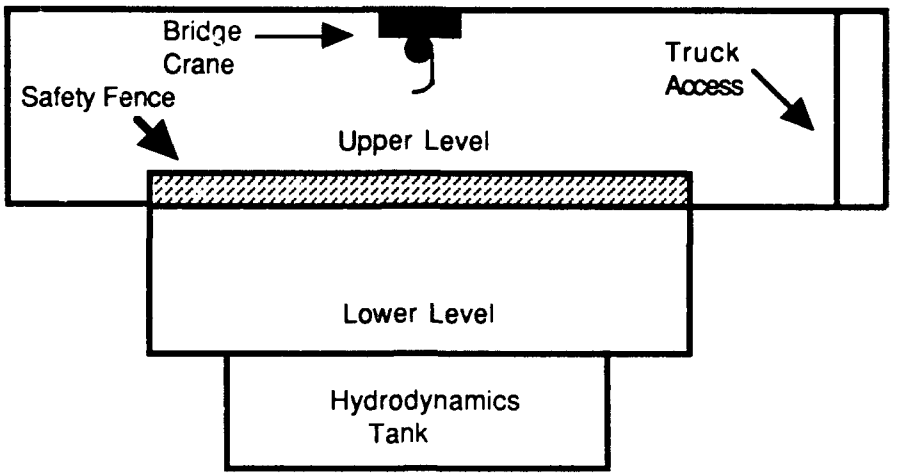
1. Facility

The only suitable building on the campus of NPS with enough room to hold the satellite and the ground support equipment was Halligan Hall. It has a high bay area similar to custom made satellite handling facilities used in industry. However, the only available space within Halligan Hall for the satellite was directly over a hydrodynamics flow tank which is recessed into the floor of the lower level. Figure 1 depicts the arrangement in Halligan Hall.

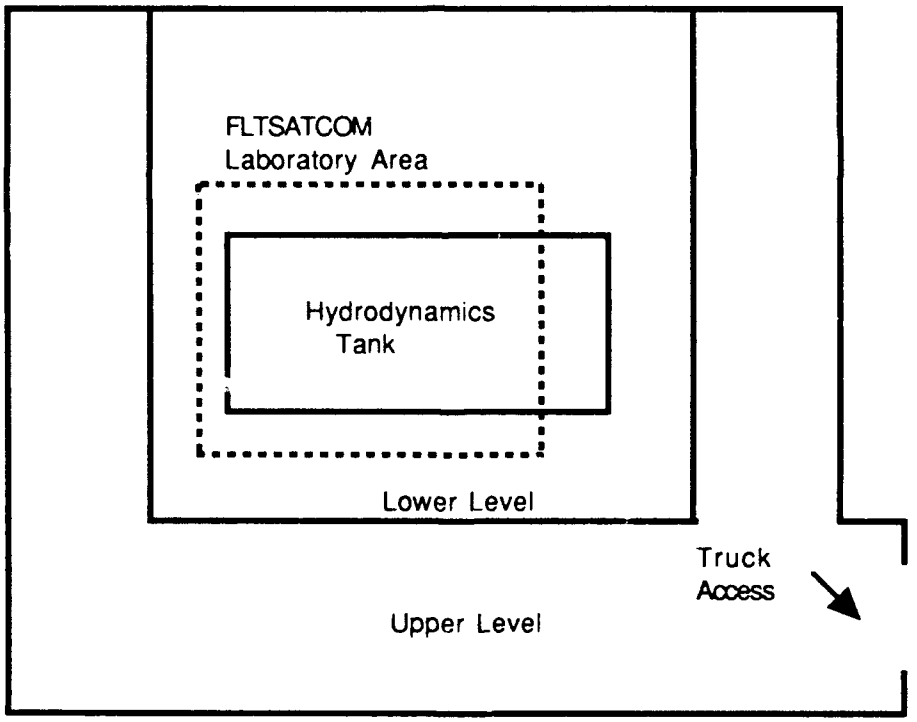
Consequently, installation of a floor over this tank capable of holding the satellite and its ground support equipment was necessary. Additionally, no electrical power connections existed in the satellite's future location and the area lacked any means (e.g., walls) to provide basic physical security. These items would have to be installed.

2. Relocation

The equipment designed for handling FLTSATCOM satellites had been used only in transfers from the TRW facility in Redondo Beach, California to the Eastern Test Range (ETR) in Florida. For these evolutions, the satellite was placed in a specially designed transport vehicle and the ground support equipment was loaded into air ride trucking vans. The satellite was flown on a C-5 aircraft to ETR; the ground support equipment was towed by truck. The satellite was



Side View



Top View

Figure 1 Halligan Hall

loaded and unloaded from the transport vehicle using bridge cranes in high bay areas. The support equipment was wheeled directly on and off the trucking van from loading docks located in the buildings at TRW and ETR.[Ref. 3]

For the transfer to NPS, a means of transporting the satellite in its transport vehicle from TRW to Halligan Hall needed to be arranged. The feasibility of using a C-5 aircraft to deliver the satellite to a location near NPS had to be investigated, as well as the towing of the satellite transport vehicle from the C-5 arrival point to Halligan Hall.

The bridge crane within Halligan Hall was too low to unload the satellite. Therefore, a method of safely removing the satellite from the transport vehicle and moving it into Halligan Hall had to be devised. Additionally, no loading dock or elevator system existed within Halligan Hall. Since the satellite and its support equipment were to be placed in the lower level, and the only building access is in the upper level, a means of lowering the satellite as well as its support equipment into the lower level had to be developed.

3. Equipment Acquisition

The satellite and the majority of its ground support equipment was owned by the government. The transfer of custody of these components to NPS could be accomplished using well established administrative procedures. However,

the majority of the components on the satellite were classified. This precluded the transfer since the area in Halligan Hall for the satellite laboratory could not be configured to meet security requirements.

Additionally, some ground support equipment essential to the operation of the satellite was owned by TRW. Either a means of legally acquiring this equipment from TRW had to be found, or the identification and purchase of acceptable substitutes accomplished.

4. Contractor Support

The expertise in handling and operating the qualification model lay exclusively with TRW personnel. The amount of support to be expected from TRW in delivering and setting up the spacecraft and the ground support equipment for operation in Halligan Hall had to be determined. Additionally, obtaining the maximum amount of training for NPS personnel in operating the satellite was desirable.

Solving these problems was essentially a twofold process. First, all actions which needed to be accomplished had to be specified in detail. This involved determining what requirements had to be met, taking into consideration the potential for problems arising due to the uniqueness of the situation. Second, decisions as to when these actions were to be accomplished and by what organizations had to be made. This required setting deadlines, establishing

priorities, and assigning responsibilities for the organizations involved in supporting the project.

This process was the essence of the project. Chapter II describes the actions which had to be accomplished to allow movement of the qualification model to NPS and its initial operation in Halligan Hall. Chapter III describes the scheduling process and assignment of responsibility for the activities detailed in Chapter II. Chapter IV critiques the accomplishment of these actions.

II. PREPARATIVE ACTIONS

This chapter discusses the problems requiring solution to allow transfer and operation of the satellite.

A. FACILITY

Substantial modifications to Halligan Hall were required to allow establishment of a satellite laboratory. The most easily solved issues were the installation of a floor over the hydrodynamics tank and walls around the satellite location in the lower level. A more difficult problem proved to be providing electrical power.

1. Floor and Walls

The design of the floor to be built over the hydrodynamics tank was based on the weight of the equipment to be placed on it. The total weight of the satellite and ground support equipment is 15472 pounds. The weights of the satellite and ground support equipment components are provided in Appendix A.[Ref. 1:p. 6; Ref. 5] The area to be covered by the floor measured 25.5 feet by 16 feet, yielding 409 square feet. Considering the weight and the area of floor to be installed, the minimum allowable strength for the design is 37.8 pounds per square foot. A contract was made by the NPS Public Works Department with CHK Enterprises, Inc., to design and install the floor for $16000. The floor type selected was of solid core plywood construction with 4 inch by 8 inch

supports beneath. This floor type is capable of holding up to 100 pounds per square foot. A Masonite surface was requested to ensure the equipment wheels would not indent the floor.[Ref. 6; Ref. 7]

Based on the experience gained from visits to the TRW facility containing the satellite, a plan was made to specify the equipment arrangement and the minimum total floor area (which included the floor to be installed over the hydrodynamics tank) required for the laboratory. This plan determined the location of the walls. Figure 2 illustrates the final floor plan.

2. Power Installation

As stated previously, no electrical power service was located in the area in which the satellite was to be placed. Appendix A lists the power requirements of the ground support equipment. The satellite itself receives power from the Power Console via the Inflight Jumper Simulator.[Ref. 8]

Investigation of the existing wiring of Halligan Hall determined that all available 220 volt and 110 volt circuits were fully loaded, precluding direct hookup of the equipment. Halligan Hall did have additional 440 volt power capacity available from its 750 kilovolt ampere (KVA) input transformer. Figure 2 also illustrates the electrical arrangement in Halligan Hall. This power source could provide the necessary 220 and 110 volt services if a transformer

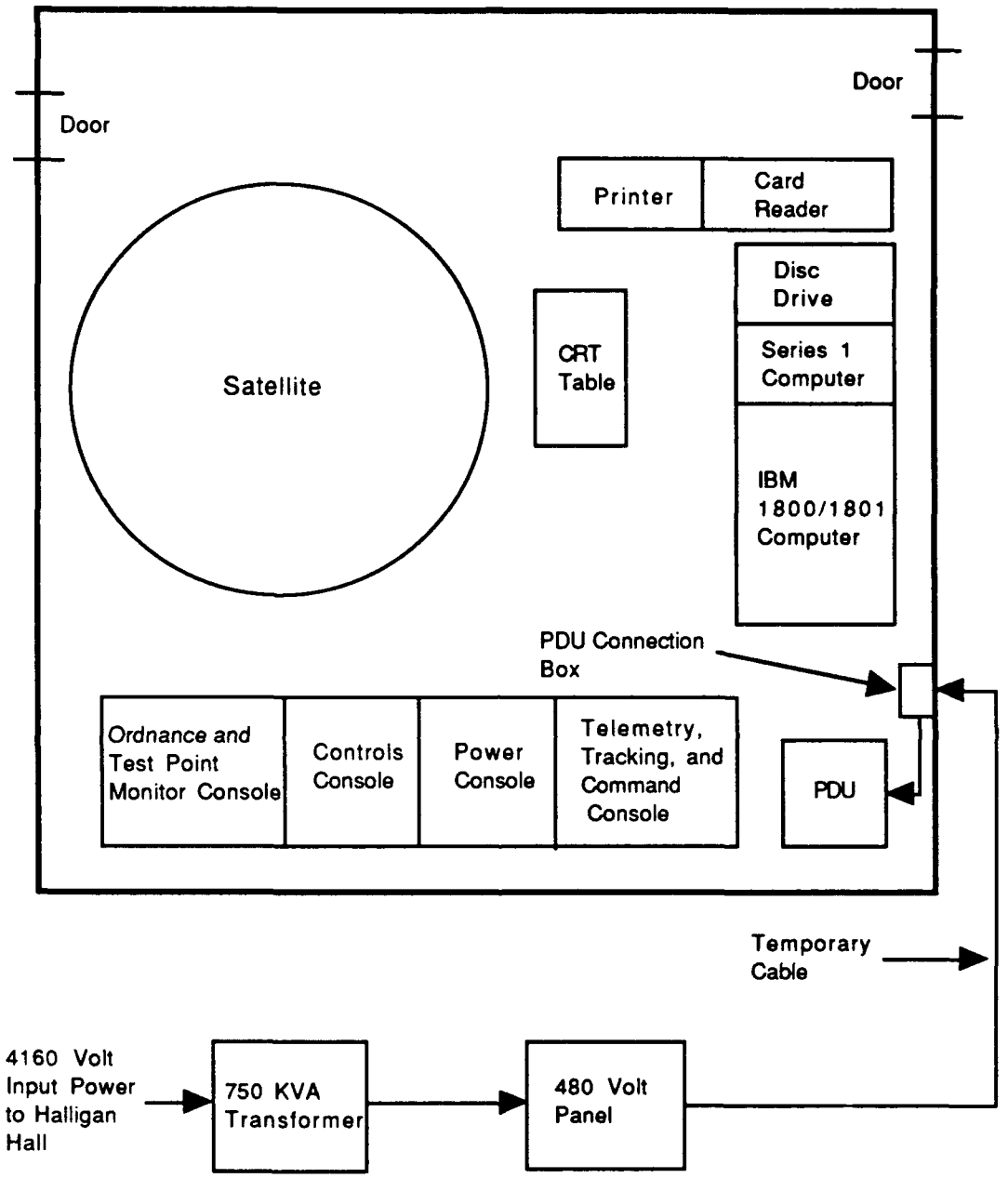


Figure 2 Laboratory Floor Plan
and Electrical Supply

system were installed. However, consultations with the NPS Public Works Department determined that there was insufficient time and funds available to accomplish this installation prior to satellite delivery.[Ref. 9]

Since operation of the satellite immediately after delivery was a desired goal, another means of supplying power to the ground support equipment had to be identified. Consultation with TRW determined that the ground support equipment was normally powered from two Power Distribution Units (PDU's), which use a 440 volt power input. One PDU could be modified to provide the necessary electrical power to all of the ground support equipment. TRW offered to include this item, with the modification completed, as part of the TRW owned equipment to be donated. TRW was also to include in the donation a connection box which allows PDU attachment to a standard 440 volt circuit breaker.[Ref. 10] Figure 2 shows how the PDU connection to the electrical system of Halligan Hall was made. Donation of TRW equipment is discussed later in this chapter.

Once the offer of a PDU was made, there only needed to be a 440 volt power source installed to service the FLTSATCOM laboratory. Installation of a 440 volt line from the 750 KVA transformer prior to the delivery of the satellite was ruled out by the NPS Publics Works Department due to time constraints and lack of materials [Ref. 11].

The option of connecting a temporary cable to an existing 440 volt circuit was explored. A 70 ampere circuit normally used to provide power to a Material Testing Machine was selected as a viable alternative [Ref. 11]. Based upon the operational experience of TRW personnel, this current capacity was sufficient to provide the power necessary for operating the ground support equipment when only powering the spacecraft bus [Ref. 12]. Since payload operation was not desired initially, this was acceptable. Accommodation by the NPS Aeronautics and Astronautics Department personnel responsible for the operation of the Material Testing Machine was arranged to allow hookup of the PDU immediately prior to satellite delivery [Ref. 13]. Coordination with the NPS Public Works Department was conducted to ensure timely installation of the temporary power connection, including the PDU connection box [Ref. 11; Ref. 14].

B. DELIVERY

1. Satellite

a. Transportation

The method for transporting FLTSATCOM satellites to ETR for launch had always been a C-5 aircraft with the satellite housed in its transport vehicle. At a meeting held on 1 December 1989, the best method to accomplish delivery of the satellite was discussed. TRW, NPS, Navy Space Systems Activity (NSSA), and USAF/SSD representatives to this meeting agreed that the optimum course of action was to attempt

to arrange delivery by C-5 into Monterey Peninsula Airport. This is the nearest air facility to NPS. Delivery by truck was ruled out because the transport vehicle is limited to five miles per hour with the satellite on board, making this option prohibitively long and expensive. An additional complication was due to the transport vehicle's width of 12 feet 3 inches, which classifies it as a wide load. Wide loads are required to travel during periods of darkness with escort vehicles on California highways.[Ref. 15; Ref. 16] These conclusions were confirmed at a meeting held at TRW on 30 Mar 1990 [Ref. 17; Ref. 18].

To arrange for the acceptance of the C-5 aircraft into Monterey Peninsula Airport, liaison was made with the Operations Manager of the airport and the Airport Military Liaison at Fort Ord Operations and Plans. Agreement was reached that the airport would configure the runway and taxiways shortly before delivery to permit use by a C-5. Specifically, since the aircraft's wings would extend beyond the edges of the runway and taxiways, all landing lights and taxiway signs would be dismantled prior to arrival of the aircraft to prevent engine damage. Additionally, the military ramp located on the north side of the airport would be made available to allow unloading of the cargo. Figure 3 depicts the arrangement of Monterey Peninsula Airport. The airport's north gate was too narrow to allow passage of the

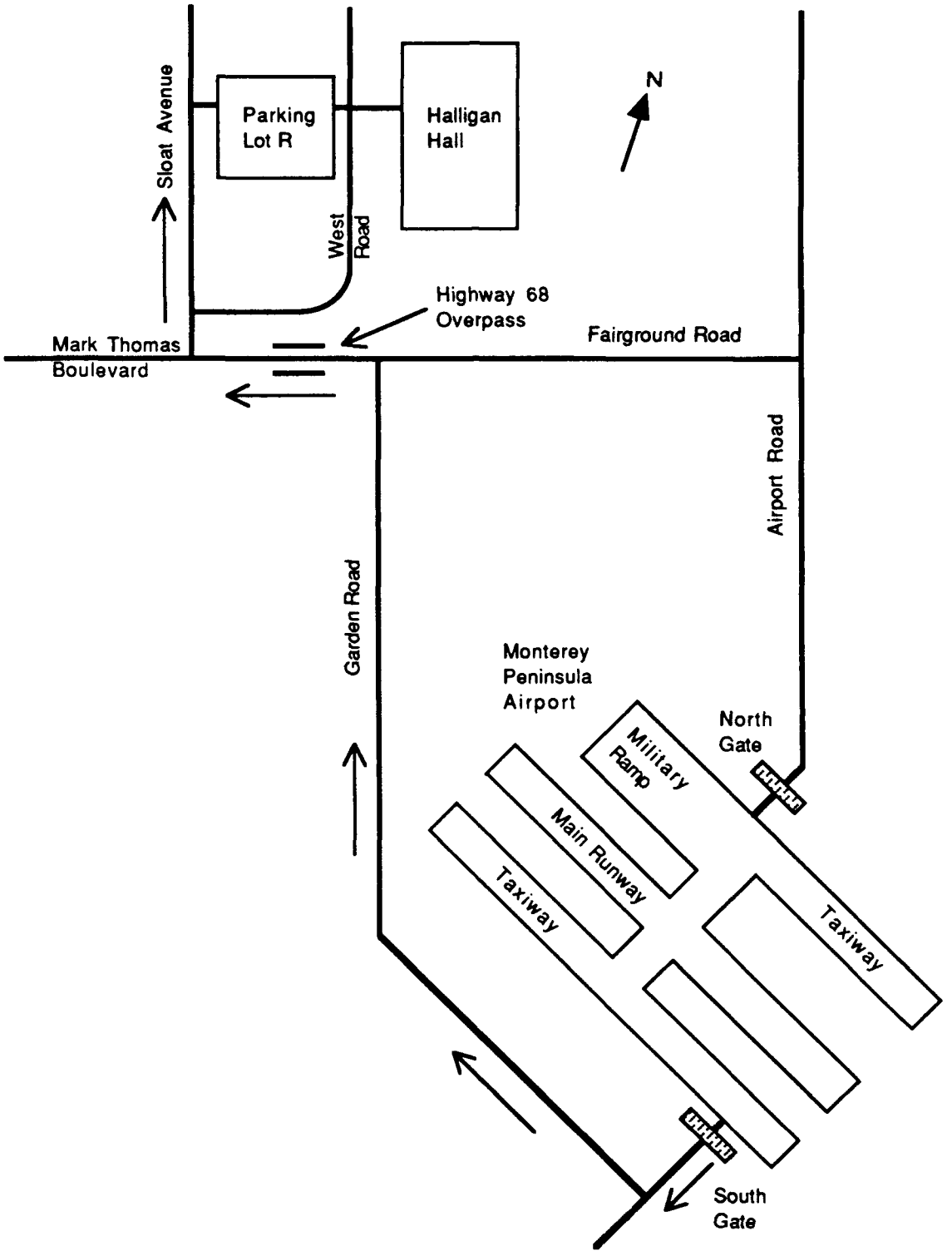


Figure 3 Transfer Route

transport vehicle. Therefore, the transport vehicle was to be towed across the runway and taxiways to a south service gate. Airport operation was to cease during this period.[Ref. 19; Ref. 20] Arrangements with the NPS security police were made to supply escort vehicles for the transport vehicle from the airport to NPS [Ref. 21]

Once the transport vehicle was clear of the airport, it would be towed via Garden Road and Mark Thomas Boulevard to Sloat Avenue, where it would enter Parking Lot R of NPS. Figure 3 also illustrates the transfer route. The entire path was verified clear of vertical obstructions to allow passage of the transport vehicle. A minimum height of 14 feet was required [Ref. 15]. Liaison with the Monterey Police department, which has jurisdiction over these roads, was established to obtain approval for towing the transport vehicle [Ref. 22]. Since these roads are not California state highways, a California Transportation Department (CALTRANS) permit was not required. CALTRANS was consulted to ensure the weight limit of the Highway 68 overpass on Mark Thomas Boulevard would not be exceeded. The weight of the transport vehicle with the satellite on board is 18400 pounds, well within the limit of 80000 pounds specified for the overpass.[Ref. 17; Ref. 23]

The intermediate dolly would accompany the satellite on the C-5. It would be used to tow the satellite from Parking Lot R to Halligan Hall. The intermediate dolly

was to be loaded onto a flatbed truck using a forklift at the airport, taken to NPS, and unloaded.[Ref. 17; Ref. 24]

Once the satellite was removed, the transport vehicle would be disposed of locally. This was planned since the transport vehicle, less the wheels, was government owned and scheduled for disposal by TRW at the conclusion of the FLTSATCOM contract. Sending it back to TRW would require keeping the C-5 at Monterey Peninsula Airport until delivery of the satellite to NPS was complete, resulting in additional cost to the government since another flight crew would have to be scheduled to meet air crew rest rules.[Ref. 17]

To accomplish disposal of the transport vehicle, arrangements were made through NPS Property Management Division to dispose of it through the Fort Ord Property Disposal Office [Ref. 25]. The transport vehicle was to be towed via Highway 68 to the East Garrison gate of Fort Ord, which enters directly into the Property Disposal area. This would require obtaining a permit from CALTRANS providing an exception to allow daytime wide load towing on Highway 68, a state highway. This route was also checked for sufficient vertical clearance. Arrangements were made with Fort Ord security for special access to the East Garrison gate, which is normally not used. Escorts for the transport were to be provided by NPS security. Once the transport vehicle arrived at Fort Ord, the wheels would be removed and returned to TRW.[Ref. 26] Two weeks prior to delivery, the Commanding

General of the 22nd Air Force decided the risk to the C-5 aircraft in performing this peacetime mission was unacceptable and directed cancellation of the flight delivering the satellite. This evaluation was based on experience gained from C-5 operations at Monterey Peninsula Airport during Operation Just Cause (Panama invasion). Consequently, USAF/SSD tasked TRW with loading the entire transport vehicle, without its wheels, onto an air ride flatbed. This flatbed would then be towed directly from TRW to NPS at normal highway speed, permitting the night time wide load towing requirement to be met. Concern existed at TRW for potential damage to the satellite since no other FLTSATCOM satellite had been handled in such a manner. However, the nearest alternate airstrip capable of receiving a C-5 was Moffett Field, and the towing time for the transport vehicle from that point was estimated to be 12 hours using state highways. The requirement to tow at night would have been difficult to meet and the cost of a C-5 flight coupled with a lengthy tow was determined to be prohibitive. Therefore, USAF/SSD, in conjunction with NSSA, made the decision to proceed with delivery using ground transport even though it was an untested method. The route for movement was checked for sufficient vertical clearance. The intermediate dolly was to be shipped on the flatbed carrying the transport vehicle.[Ref. 27; Ref. 28]

Once the satellite and intermediate dolly were unloaded, the transport vehicle would then be taken on the flatbed to Fort Ord Disposal and lifted off by forklifts at the disposal site. Local disposal was still desirable to avoid the cost of towing the transport vehicle back to TRW.[Ref. 27]

b. Unload

The method of unloading the satellite at the school was agreed upon by representatives of NPS and TRW at a meeting held at NPS on 8 May 1990. To remove the satellite from the transport vehicle, a crane with a 4000 pound minimum lift capability and a hook height of at least 38 feet was required [Ref. 26; Ref. 29:p. 8]. This was necessary due to the method of removal, which is illustrated in Figure 4. The crane is attached to the top of the satellite hoisting sling using a spacer bar with a hydraset, and then the entire assembly lifted and rotated until vertical. At this point, the combined height of the transport vehicle, hoisting sling, spacer bar, and hydraset is 38 feet. The hoisting sling is then disconnected from the transport vehicle at its base and the entire assembly lifted off. The satellite is placed on an adapter to allow switching to a lifting sling. The satellite is then lifted onto the intermediate dolly to allow towing.[Ref. 26]

The bridge crane in Halligan Hall had a maximum hook height of 23 feet, making it unacceptable for unloading

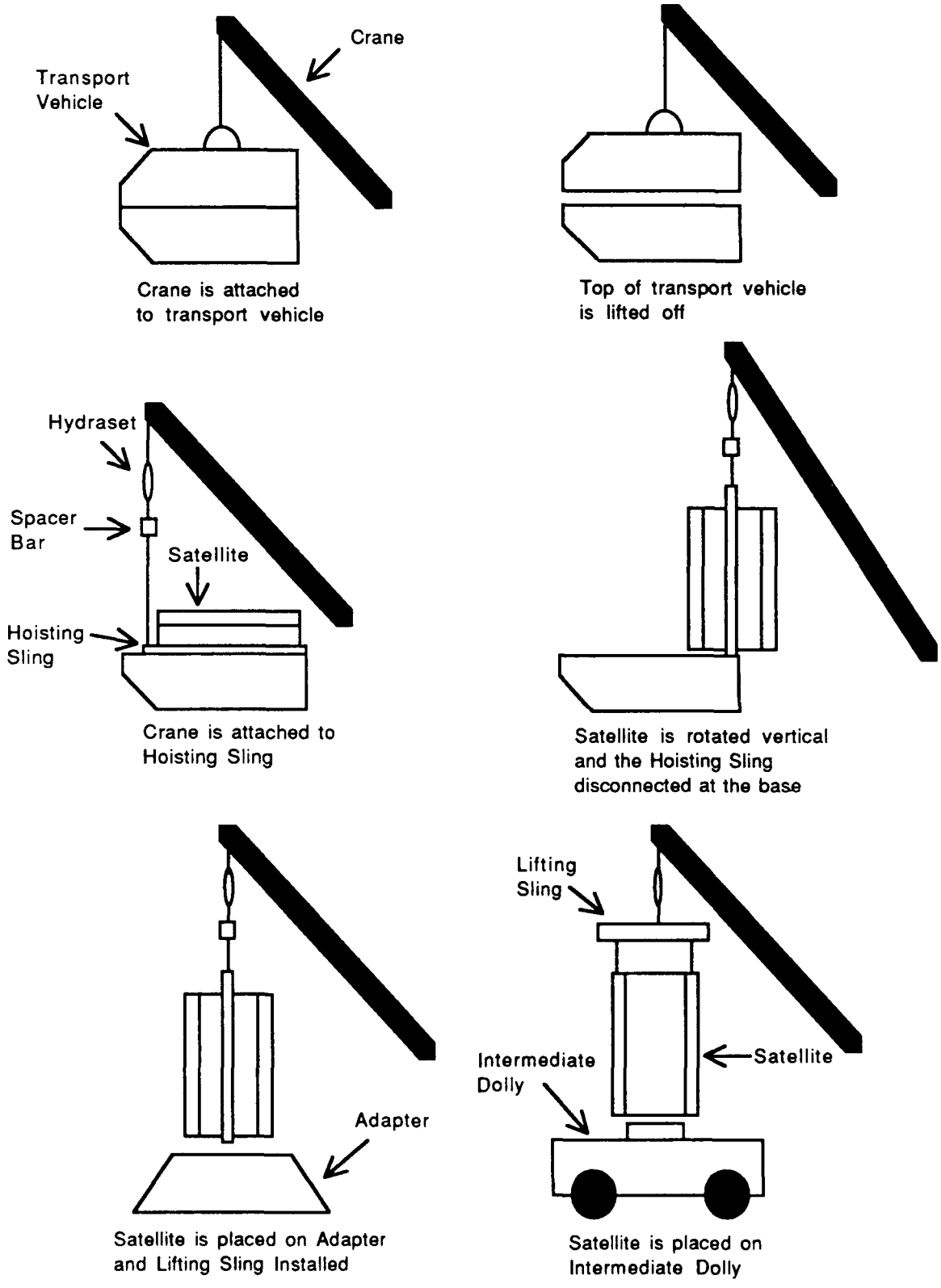


Figure 4 Satellite Unloading

the satellite. Therefore, it was decided that a mobile crane positioned in Parking Lot R would be used to remove the satellite from the transport vehicle and to place it on the intermediate dolly. The satellite could then be towed into Halligan Hall. Once there, it would be lowered into the lower level of Halligan Hall using the 7500 pound capacity bridge crane.[Ref. 26]

Essential to this plan was the identification of a suitable mobile crane. The crane normally available from NPS Public Works Department was determined to be mechanically unsound and beyond economical repair due to leaking hydraulic cylinder seals [Ref. 30]. An acceptable crane was located at Fort Ord Directorate of Housing/Operations and Maintenance Division. This crane has a 120 foot hydraulically extendible boom rated at 20 tons and the capability of operating at a very slow rate of cable advance. This crane was inspected by TRW personnel and its characteristics verified with the crane manufacturer (Grove, Inc.) to ensure its suitability. Its boom length would allow extension over the transport vehicle with sufficient hook height to raise the satellite. Arrangements were made by NPS with the Fort Ord office responsible for the crane to have it available for the unloading evolution.[Ref. 26]

Additional preparations necessary to accommodate delivery of the satellite included:

1. Clearing the necessary area in Parking Lot R to allow accomplishment of the unloading operation [Ref. 21].

2. Adjustment of the crane stop on the bridge crane in Halligan Hall. The hook height at which the stop turned off the crane motor was determined to be 21.5 feet. A minimum of 23 feet was required to lift the satellite off the intermediate dolly.[Ref. 26; Ref. 31]

3. Removal of a section of safety fence in the first level of Halligan Hall, since the bridge crane hook height of 23 feet would not be high enough to lift the satellite over it [Ref. 32].

2. Ground Support Equipment

At the meeting at NPS on 8 May 1990, it was agreed that the delivery of the ground support equipment would be accomplished using standard trucking vans prior to delivery of the satellite. This would allow setup of the ground support equipment before satellite arrival.[Ref. 26]

To allow positioning of the ground support equipment in Halligan Hall, a means to lower the equipment from the upper level to the lower level had to be devised. After considering several alternatives, the conclusion was reached that the best method would be to construct a platform capable of holding and lifting the ground support equipment with the bridge crane in Halligan Hall. The platform was to be designed for 5000 pounds capacity and tested to 2500 pounds load. This amount was based on the 2500 pound weight of the heaviest ground support component (the Telemetry, Tracking, and Command Console) and gave a 100% margin in design and a full load test prior to actual use. Additionally, a ramp that would allow rolling the equipment on and off the platform would be built.[Ref. 26]

C. CLASSIFIED SATELLITE COMPONENTS

As mentioned previously, Halligan Hall could not be configured to safeguard the satellite as a classified item. The means of resolving this issue will now be described.

1. Communications Security Components

Those items that provide communications security (COMSEC) are required to be classified by the National Security Agency instruction NACSI 4003 [Ref. 33:p. 9] .

Declassification of the COMSEC items was not an option. All of these components, except the KIR-23 decrypters and ultrahigh frequency (UHF) command decoder, are associated with payload operation and are not required to operate the spacecraft bus. Removal of these items before delivery was elected.[Ref. 34] The KIR-23 decrypters and UHF command decoder are used to pass telemetry between the satellite and the ground support equipment [Ref. 3]. To allow removal of these components, the satellite was to be configured to operate in an non-encrypted mode prior to transfer. This would allow operation of the spacecraft bus with the only effect being the generation of some error messages from the computer during startup.[Ref. 35]

2. General Service Classified Components

The classification of the remaining components, with the exception of the Air Force Narrowband (AFNB) processor, was due to the method used to provide nuclear hardening. The AFNB processor is classified because it

contains anti-jam communications circuitry used in the payload section.[Ref. 33:p. 3; Ref. 36]

Transfer of the AFNB processor to NPS was desired since it could be used in a curriculum such as Electronic Warfare. Removal of this item from the satellite and separate shipment was elected to allow its acquisition.[Ref. 17] A safe in Halligan Hall was obtained through the NPS Security Manager to permit stowage near the laboratory.

Declassification of the remaining items was sought since separate secure stowage would require installation and removal in support of satellite operating periods. This would not be practical due to the number of components involved.

The governing instruction directing classification of these components was the Department of the Navy Security Classification Guidance for Communications and Satellite Programs (OPNAVINST S5513.6). The administration of this instruction is the responsibility of the SPAWAR Radio Frequency Communication Satellite Group [Ref. 37]. Consultation with SPAWAR representatives determined that the next version of this instruction (OPNAVINST S5513.6C) would delete the need to classify components based on their nuclear shielding [Ref. 38]. Liaison with USAF/SSD determined that once this revised instruction was issued, a revision to the FLTSATCOM Security Classification Guide could be issued by the Security Police/Information Security Division component of their

office which would authorize declassification of the items. In conjunction, USAF/SSD would issue a change to the FLTSATCOM contract allowing TRW to ship the satellite to NPS as unclassified material.[Ref. 39]

D. ACQUISITION OF TRW OWNED EQUIPMENT

The ground support equipment which was owned by TRW is listed in Appendix B [Ref. 40]. Each of these components is necessary to allow the operation of the satellite. At the beginning of the project, TRW expressed a willingness to donate all of the equipment except the PDU to NPS. Once the need for the PDU was identified, TRW included this component in the offer.[Ref. 41]

To permit this donation, a means to accomplish it without violating accepted standards of conduct in government contracting had to be found. Since TRW is a major defense contractor and NPS is a U.S. Navy organization, a donation directly to the school could have the appearance of an infraction.[Ref. 42:p. 34] To avoid this, two options existed. One possibility was donating the equipment to the Secretary of the Navy. The other choice was to have TRW donate the equipment to the NPS Foundation, Inc., a non-profit organization whose purpose is to support the school.[Ref. 43; Ref. 44] The decision to use the NPS Foundation was made because this organization is located on campus, allowing easier and more timely coordination.

An initial proposal was made to the NPS Foundation Gift Committee by the Chairman of the SSAG [Ref. 45]. The NPS Foundation Chairman, Gift Committee Chairman, and legal counsel determined that a written offer by TRW to donate the equipment was necessary to permit the NPS Foundation to accept the donation. Once the equipment arrived, a formal transfer of custody between TRW and the NPS Foundation could then occur.[Ref. 46] To allow TRW to claim the donation for tax purposes, TRW required certification of the NPS Foundation's tax exempt status [Ref. 47].

After delivery, the value of the equipment would be assessed and the NPS Foundation would then make a bailment agreement with the school to permit the equipment's use in the laboratory.[Ref. 46]

E. SETUP AND INITIAL OPERATION

The setup and startup of the satellite in Halligan Hall would require accomplishment of the following steps:

1. Installation of the power cable to the PDU connection box.
2. Connection of the cabling between the ground support equipment components, including the connection of the PDU to its connection box [Ref. 48:p. 28].
3. Validation of the operability of the ground support equipment [Ref. 48:p. 28].
4. Connection of the ground support equipment to the satellite [Ref. 48:pp. 28-29].
5. Satellite startup and testing [Ref. 48:p. 5].
6. Operation of the satellite to perform initial training of NPS personnel.

III. SCHEDULING AND ASSIGNMENTS

Chapter II described the actions necessary to accomplish the transfer of the satellite and establishment of the FLTSATCOM laboratory. The determination of these requirements was relatively straightforward once the unique circumstances of the project were evaluated. A more difficult task was determining a schedule and assigning responsibility for the completion of these actions.

The scheduling of preparative actions, delivery, and setup was complicated by TRW's intention to use the qualification model for a test of arcjet thrusters for the National Aeronautics and Space Administration (NASA) prior to its delivery to the school. Completion of this testing before the FLTSATCOM contract expiration date of 20 June 1990 was originally planned. At a meeting attended by representatives of USAF/SSD, NSSA, SPAWAR, TRW, and NPS on 30 March 1990, TRW forecasted that this completion date would not be achieved due to a delay in receiving materials necessary for the arcjet testing. Agreement was reached at this meeting that an extension of the contract would not affect any planned course offerings at NPS and that completion of the arcjet test for NASA was desirable. Additionally, it was agreed that regardless of the actual date of delivery, the ground support equipment would be delivered approximately

two days prior to the satellite to allow its hookup and validation to occur in preparation for satellite testing.[Ref. 15; Ref. 17; Ref. 18]

An extension of the contract deadline was formally requested by TRW [Ref. 40]. In response, the contract was extended to 15 August 1990 by USAF/SSD [Ref. 49]. In consideration of receiving the extension, TRW offered to provide assistance in the initial setup and operation at NPS [Ref. 40].

Based upon liaison between USAF/SSD, TRW, NSSA, and NPS during the period of May to June 1990, the best estimate for the earliest possible satellite delivery date was subsequently determined to be 1 August 1990. This estimate was predicated upon the most optimistic schedule for the arcjet testing at TRW. All preparative actions were planned based upon this date for satellite delivery.[Ref. 26; Ref. 50]

A. PREPARATIVE ACTIONS

Figure 5 illustrates the sequence necessary for accomplishing all preparative actions to support delivery of the satellite and the ground support equipment. Based upon the estimated date for satellite delivery of 1 August 1990, the following goals and assignment of responsibility for completion were set.

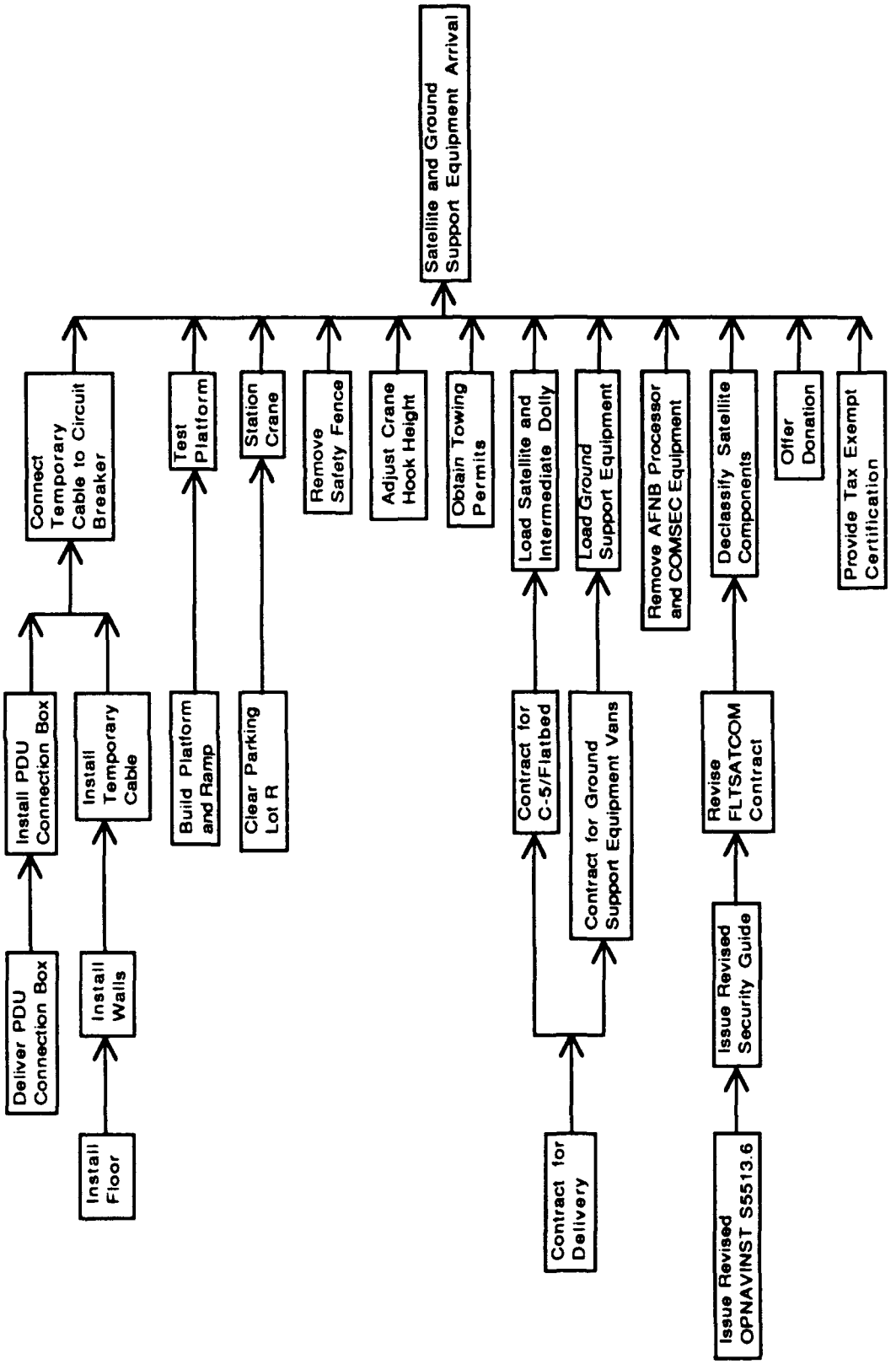


Figure 5 Sequence of Preparative Actions

1. Facility

a. Floor

The floor installation was specified in the contract with CHK Enterprises, Inc., to be complete by 1 June 1990. This would allow installation of walls prior to delivery of the satellite and ground support equipment. The responsibility for initiating the contract and ensuring its completion was given to the Laboratory Manager of Halligan Hall. The contract was arranged through the NPS Public Works Department.[Ref. 6]

b. Walls

The erection and painting of the walls for the laboratory was set to occur prior to 15 July 1990. This assignment would normally have been given to the NPS Public Works Department, which would have then initiated a contract. However, the NPS Public Works Department could not guarantee completion of the walls prior to delivery of the satellite. Therefore, the decision was made to have the walls built by members of the Aeronautics and Astronautics Department and to have the painting accomplished by members of the SSAG staff with the assistance of student volunteers.[Ref. 51]

c. Power Connection

TRW agreed to a request by NPS to deliver the PDU connection box two weeks prior to the arrival of the ground support equipment [Ref. 52]. Installation of the PDU

connection box and the temporary cable could then occur simultaneously, thereby minimizing the number of man hours required. The temporary cable was not to be connected to the supplying circuit breaker until one working day prior to delivery of the ground support equipment, thereby allowing use of the Material Testing Machine for the maximum amount of time. Responsibility for the installation of the PDU connection box and the temporary power cable was assigned to the NPS Public Works Department.[Ref. 53]

2. **Delivery**

a. Transportation

The contracting for the transportation of the satellite and the ground support equipment was to be done approximately two weeks prior to delivery. USAF/SSD had the overall contracting responsibility.[Ref. 26]

TRW was contracted by USAF/SSD to arrange for the trucks and air ride vans to ship the ground support equipment [Ref. 54]. Three Way Van Lines was hired by TRW to do so [Ref. 55]. When the decision was made to use ground transport for the satellite as well, USAF/SSD added shipment of the satellite to the contract with TRW [Ref. 54]. Three Way Van Lines was also used by TRW to provide the air ride flatbed for the satellite transport vehicle [Ref. 55]. The loading of the equipment into the air ride vans and the satellite into the transport vehicle/air ride flatbed combination was to occur immediately prior to departure. All

loading of the satellite, transport vehicle, and the ground support equipment was to be accomplished by TRW personnel. This arrangement for responsibility was part of the agreement between USAF/SSD and TRW to allow extension of the original FLTSATCOM contract.[Ref. 40] All CALTRANS permits were the responsibility of Three Way Van Lines. Coordination with CALTRANS was performed by NPS for the permit allowing towing of the transport vehicle on Highway 68 to Fort Ord Property Disposal during daylight [Ref. 55].

b. Local Delivery Preparations

The design, construction, and testing of the platform and ramp to be used in lowering the ground support equipment was assigned to the Laboratory Manager of Halligan Hall [Ref. 26]. The clearing of Parking Lot R was to be performed by NPS Security the day prior to delivery of the ground support equipment. It would remain cleared until satellite delivery was complete.[Ref. 21] The removal of the section of railing in Halligan Hall and the adjustment of the crane stop was assigned to the NPS Public Works Department and was to be accomplished the day prior to satellite delivery [Ref. 32].

The crane was to be on station immediately prior to delivery of the satellite. The operator of the crane would be supplied by the Fort Ord Directorate of Housing/Operations and Maintenance Division. The operator

was to be briefed by TRW personnel immediately prior to unloading the satellite.[Ref. 26]

3. Classified Components

a. Equipment Removal

Removal of the COMSEC equipment and the AFNB processor was to occur prior to the start of the arcjet testing at TRW. This equipment removal would be done by TRW. The shipment of the AFNB processor was to be accomplished by TRW in conjunction with delivery of the ground support equipment. TRW would maintain custody until arrival, at which time it would then be transferred to NPS personnel.[Ref. 17]

b. Equipment Declassification

No firm deadlines were set for the individual steps necessary to declassify the remaining components except to request each be done as soon as possible. The completion of the entire series of steps was necessary before satellite delivery. The revision to OPNAVINST S5513.6 was the responsibility of SPAWAR Radio Frequency Satellite Communication Group and the change of the FLTSATCOM Security Classification Guide that of USAF/SSD Security Police/Information Security Division. USAF/SSD had the responsibility of issuing a change to the FLTSATCOM contract to direct TRW to declassify the satellite components.[Ref. 38; Ref. 39]

4. TRW Donation

The steps necessary to allow the donation of TRW owned equipment were also not assigned separate deadlines. Completion of these actions was necessary prior to delivery of the ground support equipment.

The written offer of the donation was the responsibility of the TRW contracting department [Ref. 56]. The SSAG office of NPS, in coordination with the office of the Superintendent, was required to accomplish the delivery of the tax exempt certification of the NPS Foundation to TRW via USAF/SSD.

B. DELIVERY, SETUP, AND INITIAL OPERATION

Figure 6 illustrates the sequence of events which were scheduled to occur once delivery of the satellite and ground support equipment was made. As discussed earlier, the ground support equipment was to arrive in sufficient time to be unloaded, connected, and validated to allow the immediate connection of the satellite upon its arrival. The time necessary for these steps was estimated to be three days.[Ref. 17]

Since the same personnel would be responsible for unloading the ground support equipment and the satellite, TRW desired that both occur in the same calendar week to minimize the time these personnel were in Monterey [Ref. 18]. Therefore, delivery of the ground support equipment was scheduled to be on a Monday with a Wednesday satellite

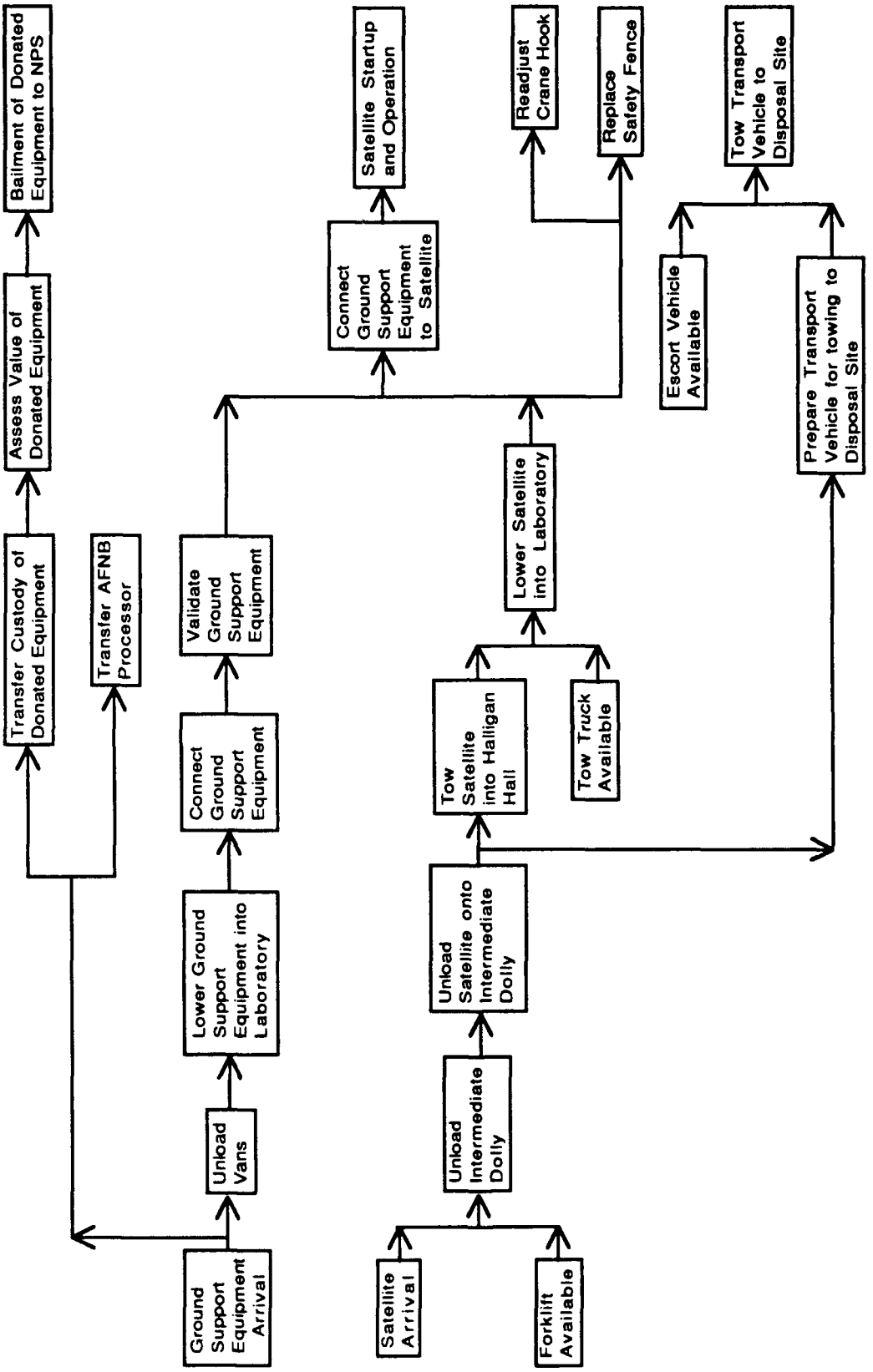


Figure 6 Sequence of Delivery Actions

delivery. This would help ensure completion of both unloading evolutions in the same week if any delay in satellite delivery occurred. Given this consideration, a delivery date of 30 July 1990 was set for the ground support equipment assuming a 1 August 1990 satellite delivery.[Ref. 50]

1. Ground Support Equipment Delivery

The unloading of the equipment from the truck was the responsibility of TRW [Ref. 40]. The lowering of this equipment into the lower level of Halligan Hall was the responsibility of the Laboratory Manager of Halligan Hall, with assistance from personnel from the Aeronautics Department, SSAG, and TRW. The entire evolution was planned to occur on the day of delivery.[Ref. 26]

2. Satellite Delivery

The entire evolution of unloading the satellite from the transport vehicle, with the exception of crane operation, was to be accomplished by TRW personnel [Ref. 40]. The Fort Ord crane operator would be directed by a TRW supervisor [Ref. 26]. NPS Public Works Department was to provide the forklift and tow truck with operators for unloading the intermediate dolly and towing the satellite into Halligan Hall [Ref. 57]. The lowering of the satellite into the lower level was also to be done by TRW personnel, with NPS Aeronautics Department personnel operating the bridge crane under TRW supervision. The satellite was to be placed in Halligan Hall on the day of delivery.[Ref. 50]

3. Setup and Operation

The connection and validation of the ground support equipment was the responsibility of TRW as part of the agreement with USAF/SSD to extend the FLTSATCOM contract. This would be done with the assistance of SSAG staff personnel and was to be accomplished in the two days following delivery of the ground support equipment.[Ref. 40; Ref. 58]

After delivery of the satellite, TRW was to connect it and start operation. This was expected to occur the day following satellite delivery, with assistance of SSAG staff personnel. Once the satellite was operational, any remaining time left in the TRW commitment to provide assistance in satellite operation was to be used in training NPS personnel.[Ref. 50]

C. MISCELLANEOUS ACTIONS

1. Transport Vehicle Disposal

Upon removal of the satellite, TRW personnel were to reassemble the transport vehicle using the crane and operator from Fort Ord. It would then be towed using the truck from Three Way Van Lines to Fort Ord Property Disposal. NPS Property Management was to ensure access through the East Garrison Gate and the availability of forklifts at the disposal site capable of lifting the transport vehicle off the flatbed truck. NPS Security was responsible for providing an escort for the wide load. The disposal of the

transport vehicle was scheduled to occur the same day as satellite delivery to allow the earliest possible release of TRW personnel and the towing truck.[Ref. 26; Ref. 50]

2. **Restoration of Halligan Hall Equipment**

The replacement of the section of fence removed to allow movement of the satellite into the lower level was scheduled to be done by the NPS Public Works Department the day after satellite delivery. The crane stop was also to be readjusted to its original position the same day by the NPS Public Works Department.[Ref. 59]

3. **Completion of Donation Procedures**

The transfer of custody of the donated equipment was to occur between TRW supervisors and the NPS Foundation Chairman upon delivery. Assessment of the value would be provided by the SSAG to the NPS Foundation. The NPS Foundation requested completion of this assessment within two weeks following delivery. Bailment of the equipment to the school would be the responsibility of the NPS Foundation; no deadline for bailment was set.[Ref. 44]

IV. PROJECT ACCOMPLISHMENT

In this chapter the accomplishment of the actions explained in detail in the previous two chapters will be described. The discussion will be limited to those items which presented particular difficulty or required extensive monitoring to ensure completion. For those items not specifically addressed in this chapter, the preparations and planning described previously were sufficient and the actions occurred as planned. This chapter will also briefly describe the arrangements made to publicize the satellite delivery and the establishment of the laboratory.

A. CRITIQUE OF ACCOMPLISHMENT

1. Preparative Actions

The extensive coordination done to ensure facility preparation, development of ground support equipment and satellite unloading methods, and determining the method of transporting the satellite has already been described. This planning was essential to guarantee proper completion of all tasks.

The declassification of the satellite components required particular attention due to the number of organizations involved in the process. Each responsible group had to be separately briefed on the need for timely performance. NPS and USAF/SSD personnel synchronized efforts to ensure

completion of these actions. The modification of the FLTSATCOM contract to direct declassification was done in conjunction with the extension of the contract expiration date [Ref. 49].

TRW initially desired to deduct the cost of the labor involved in transporting and setting up the satellite as a charitable contribution. The NPS Foundation was unwilling to provide certification to TRW regarding its tax exempt status as a result.[Ref. 60] This complication was eliminated when TRW agreed to provide the labor in return for having the FLTSATCOM contract extended to allow completion of the arcjet testing [Ref. 40].

2. Delivery and Setup

The ground support equipment was delivered successfully as scheduled on 29 July 1990. The connection of the ground support equipment was accomplished without any problems. During the course of the hookup, TRW personnel recommended the establishment of an earth ground to provide equipment protection in the event of an electrical storm [Ref. 61]. This action was accomplished by SSAG personnel.

The validation of the ground support equipment was initially delayed by approximately six hours due to the improper phase sequence of the input 440 volt electrical power to the PDU. The NPS Public Works electrician who performed the connection had done so correctly; the labeling of the phase sequence in the circuit breaker panel was

incorrect. The sensitivity of the PDU to phase sequence was known beforehand. This problem could have been averted by actually measuring the phase sequence prior to connection.

Another more significant delay in ground support equipment validation occurred when the IBM 1800/1801 mainframe computer failed to initialize properly. TRW lacked personnel with experience in troubleshooting this computer. This was resolved by having NPS hire a technical expert recommended by TRW. The technical expert repaired the problem, which was isolated to the card reader. This difficulty delayed validation two days. The time required to issue the contract to hire the technical expert was minimized through advance preparation of the contract by the SSAG staff in anticipation of such a problem.

The satellite itself was delivered on schedule on 1 August 1990 and was successfully started up on 3 August 1990. TRW personnel remained at NPS until 9 August providing training to NPS personnel in operation of the satellite.

The donated equipment was assessed at a value of $151,220 [Ref. 62]. This value was reached by using manufacturer prices for the cost of identical or similar equipment. Appendix B provides the breakdown of the donated equipment's assessed values. Bailment of the equipment to the school was subsequently accomplished [Ref. 63].

B. PUBLIC AFFAIRS

Part of this project involved publicizing the delivery of the satellite. The objective for this was twofold: formal recognition of the contributions made by the organizations involved and advantageous publicity for the school.

The publicity for the delivery of the satellite and establishment was coordinated through the NPS Public Affairs Office, USAF/SSD Public Affairs Office, and TRW's Public Relations Office. Coverage by the media was arranged to occur during one specific period to allow full and equal access by interested news organizations. This yielded very positive results. A formal dedication ceremony was held separately, during which the efforts of the key contributors to the project were recognized.

C. CONCLUSION

This project resulted in a significant advancement in the capability of NPS to educate students in space systems by establishing the first university laboratory using an operational satellite. The delivery of the FLTSATCOM qualification model satellite has given NPS a unique opportunity to further the value of the Space and Astronautics curricula.

APPENDIX A

GROUND SUPPORT EQUIPMENT CHARACTERISTICS

Equipment	Weight(pounds)	Voltage	Amperage(1)
Satellite	1852	(2)	(2)
Telemetry, Tracking, and Command Console	2500	110	30
Controls Console	2400	110	30
IBM 1800/1801 Computer	2000	220	60
Power Console	1600	220	50
PDU	950	440	(3)
Ordnance and Test Point Monitor Console	800	110	15
Battery Simulator (4)	800	110	15
Blockhouse Console (4)	800	110	15
Disc Drive	550	110	15
Card Reader	520	110	15
Printer	400	110	15
Series 1 Computer	300	220	30

(1) These currents exist under maximum design load.

(2) The power to the satellite is supplied from the Power Console via the Inflight Jumper Simulator.

(3) The PDU current load is dependent on the demand of the components it is supplying.

(4) These components are not used during normal operations.

APPENDIX B

EQUIPMENT DONATED BY TRW

Item	Cost Estimate
Harrison Labs 6266A Power Supply	1800
Harrison Labs 6267A Power Supply	1625
Hewlett Packard 6475C Power Supply	11500
Power Control	895
Intermediate Dolly	5000
Power Console	2810
Hewlett Packard 6267B Power Supply	1750
Primary Monitor Control	895
DANA 5900 Digital Voltmeter	3600
Intercom	2800
Three Hewlett Packard 6443B Power Supplies	5550
Telemetry, Tracking, and Command Console	4215
Patch Panel	2800
Primary Power Control	895
Datatron Time Code Generator	2640
Telemetry Simulator	11200
Switching Panel	2800
Oscilloscope	3000
Patch Panel	2800
Pulse Code Modulation Communication System	8700
Telemetry Buffer	11200
Baseband Assembly	11200
Patch Panel	2800
Wavetek 132 Noise Generator	1590
Printer Keyboard	375
Inflight Jumper Simulator	895
Hewlett Packard P245L Electronic Counter	2640
Phase Shift Keying Demodulator	9900
Command Buffer	395
Digital Command Selector 4270	8700
Battery Trickle Charger	2500
Hewlett Packard 6267B Power Supply	1750
Power Distribution Unit	20000

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